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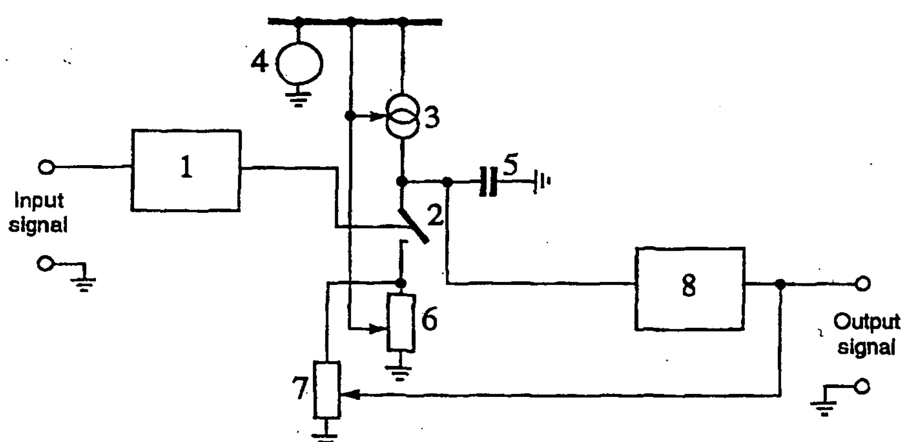


**(57) Abstract**

The apparatus comprises a circuit where an input electric signal is connected to a constant pulse duration generator (1), after which there is connected a switch (2) which is connected to a primary current source (3), connected between a supply voltage source (4) and a capacitor (5), and one pole of said capacitor (5) is connected between the switch (2) and the primary current source (3), while after the switch (2) there is connected a main load (6), consisting of a circuit for taking away the constant charge quantity from the capacitor (5) within the ON position of the switch (2). The main load (6) is advantageously connected to the supply voltage source (4), and between the capacitor (5) and the output of the apparatus there is connected a frequency low-pass filter (8). To the output of the apparatus there may be connected an auxiliary constant current load (7), one pole of which being connected either to the capacitor (5) or between the switch (2) and the main load (6). Alternately, to the output of the apparatus, there may be connected the secondary constant current source (9), one pole of which being connected either to the output of the apparatus and to the capacitor (5), or to the switch (2) and to the main load (6).

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# APPARATUS FOR CONVERTING FREQUENCY OF AN ELECTRIC SIGNAL TO VOLTAGE

## TECHNICAL FIELD

The invention is in the sphere of electrical engineering. It is an apparatus for converting frequency of an electric signal to voltage. There is designed a combination of elements for the circuit of said apparatus, and there is also solved their arrangement and wiring.

## State of the Art

At present, various systems are used for converting frequency of an electric signal to voltage.

The known system, described by National Semiconductor (LM2907/LM2917 Frequency to Voltage Converter, Circuit Description, February 1995), includes an input comparator, a circuit for linear charging and discharging of a timing capacitor, a timing capacitor, a current mirror, an outlet resistor and a filtering capacitor. This system is functioning in such a way that after having changed the input voltage through the reference voltage of the comparator, the charging or discharging of the timing capacitor takes place. Said charging or discharging is linear, and voltage across the capacitor passes from one voltage level to the other, where the difference of said voltage levels is equal to one half of the supply voltage VCC. Within a half-period of the input signal, the change of the charge of the timing capacitor C is as follows:

$$DQ = (VCC/2) \times C$$

(where D = delta)

The average current value i/AVG/, by which the timing capacitor is charged or discharged is as follows:

$$i/AVG/ = VCC \times fin \times C$$

where fin represents frequency of the input signal.

Said average current is led through the current mirror to a resistor load R which is connected to the grounding potential. Current pulses are then filtered by the filtering capacitor CF. For output voltage Vo, there is approximately valid the following equation:

$$Vo = VCC \times fin \times C \times R$$

Disadvantages of said system reside in the dependence of the output voltage upon changes of the supply voltage, dependence upon changes of the capacity of the capacitor by the effect of thermal and time influences, and in its low selectivity.

As to another system described by Motorola (Communications Device Data, DL 136/D, l995, Application Notes AN 535, p. No. 4-8), its electric periodical input signal is connected to a phase detector, after which a frequency low-pass filter is connected, and after that, a voltage-controlled oscillator follows. The output of the oscillator is connected backwards through a frequency divider to a phase detector. The conversion of the electric signal frequency to voltage is realized in such a way that the phase of the input signal is compared with the signal phase of the oscillator divided by the frequency divider with the detector. The resulting error signal passes through the frequency low-pass filter and tunes the oscillator automatically until the phase and frequency of the divided oscillator frequency are identical with the input signal. The control voltage across the oscillator is directly proportional to the frequency of the input signal. The disadvantage of such a solution is that it

requires application both of a voltage-controlled oscillator having linear properties and a large-range tuning ability and of a phase detector. Both of these are relatively costly.

As to another system described by National Semiconductor (LM131A/LM131, LM231A/LM231, LM331A/LM331 Precision Voltage-to-Frequency Converters, Circuit Description, December l994), its periodical input signal is connected to a derivative element. After it, there is connected a constant pulse duration generator. Said generator is connected to a switch which, in the ON position, switches the constant current source to the capacitor and to a parallelly connected resistor, to which the output of the apparatus is then connected. The conversion of the electric signal frequency to voltage is realized in such a way that the input signal is first formed by means of the derivative element, and then said signal starts the pulse generator. The pulse switches the switch which charges, within the period of the switched-on state, the capacitor from the constant current source. After the end of the pulse, the switch is switched off and the capacitor is discharged into a connected resistor. Disadvantages of this solution are in its low selectivity, its limited frequency range, its need for application of precise heat stable components and in its need to design the constant current source in such a way that it may be independent of the supply voltage.

In US patent No. 4.222.095, an apparatus is described wherein the input electric signal is connected to the pulse generator, after which there is a switch being connected to a primary current source which is connected between a supply voltage source and a capacitor. One pole of the capacitor is connected between the switch and the primary current source. As the pulse generator, there is applied a circuit for generating a pulse with a variable duration. That is why the pulse duration is variable and proportional to the input frequency. Said circuit is not able to secure a frequency-to-voltage conversion, but it serves only for determining the reference voltage which is variable. For the frequency-to-voltage conversion, it is necessary to connect an additional circuit which is

described in said US patent in the form of a rather complicated circuit that includes a D-type flip-flop and a circuit for modifying the time constant. The disadvantage of said method resides in its considerable costs, in its limited frequency range and in its low selectivity.

## DISCLOSURE OF INVENTION

The above-mentioned drawbacks may be obviated by the solution according to the invention. There is designed an apparatus for converting frequency of an electric signal to voltage, where the input periodical electric signal is connected to a constant pulse duration generator, after which there is connected a switch, being connected to a primary current source and a capacitor. One pole of the capacitor is connected between the switch and the primary current source which is connected to a voltage source, i.e., supply voltage source. The other pole of the capacitor may be grounded or connected to another potential. As to said connection, there may be connected the main load after the switch. The main load consists of a circuit for taking away the constant charge quantity from the capacitor within the ON position of the switch. That is why the quantity of the charge, taken away from the capacitor, is constant and independent of voltage across the capacitor. Generally, said quantity may be controlled by control voltage, which means, as to the circuit arrangement according to the invention, that it may be controlled by means of the supply voltage. It results, from the above-mentioned conditions, that as the main load there may be applied, e.g., a circuit of a transconductance operational amplifier, or a circuit consisting of an operational amplifier, of a field-effect transistor and of a resistor, or a circuit consisting of a bipolar NPN transistor, of a capacitor connected between the emitter of said transistor and the grounding potential, and of a discharging switch. In this way it is also explained that as the main load there cannot be applied, e.g., a resistor, a resistance of a channel of a field-effect transistor, an integrating element, or another impedance. A pulse generator for generating pulses with a constant

duration may be made as an integrating circuit, or it may consist of mutually interconnected elements. By arranging and connecting the circuit according to the proposed solution, there is created an apparatus for converting frequency of the input electric signal to the output voltage, where the conversion is highly selective and the influence of changes of the supply voltage is suppressed. Thermal influences are also simultaneously suppressed. At the mentioned connection of the switch and of the capacitor, the output voltage at a zero frequency is only a little lower than the supply voltage, and with the increasing frequency the output voltage decreases. The capacitor need not be of a very high quality, which decreases costs for the apparatus. The apparatus does not require expensive materials.

The main load is advantageously connected at the same time to the supply voltage source, so that it is controlled by the supply voltage; the primary current source is controlled by the supply voltage as well.

If additionally a frequency low-pass filter is connected into the above-mentioned circuit, viz., between the capacitor and the outlet of the apparatus, the voltage ripple across the output of the apparatus, caused by charging and discharging the capacitor, is suppressed. The apparatus may be functioning even without the frequency low-pass filter, eventually without a connection to the control of the above-mentioned elements by means of the supply voltage, but the achieved function result of the apparatus provided with the wiring, according to this paragraph and the preceding one, is considerably better.

The wiring according to the preceding paragraph has two alternatives. In the circuit of the apparatus an auxiliary constant current load may be connected to the outlet of the apparatus, so that it is controlled by the output voltage. Alternatively, to the circuit of the apparatus, there may be connected a secondary constant current source which is connected to a voltage source, i.e., supply voltage source, and it is connected to the outlet of the apparatus, so that

it is controlled by the output voltage. In this way, the slope of the electric signal frequency-to-voltage conversion can be affected.

Both alternatives mentioned in the preceding paragraph have two possibilities of a particular wiring which must be selected from with respect to the required kind of conversion slope control and to the application of the apparatus.

As an auxiliary load, there may be applied only a constant current load, unlike for the main load which may be in the form of a constant current load or of another load, on the condition that a constant charge quantity is taken away when the switch is in the ON position. The auxiliary constant current load may be at a connection when it is controlled by means of the output voltage, connected alternatively either to the capacitor or between the switch and the main load.

The auxiliary constant current load is a term generally meant to mean a circuit through which constant current passes, being independent of the value of the voltage source to which the auxiliary load is connected, and in case of the invention, it is the capacitor. In the case that one pole of the auxiliary load is connected to the capacitor, said connection is direct; in the case that said pole is connected between the switch and the main load, it concerns the connection to the capacitor through the switch. The value of the passing current is controlled, as to the auxiliary constant current load, by control voltage, which is represented, in the case of the invention, for all alternatives, by the output voltage. From the above-mentioned facts, it is evident, that as an auxiliary constant current load, there may be applied, e.g., a transconductance operational amplifier, or a circuit consisting of an operational amplifier, of a field-effect transistor and of a resistor. As an auxiliary constant current load, there cannot be applied, e.g., a resistor, a resistance of a channel of a field-effect transistor, integrating element or another impedance, or a circuit

consisting of a bipolar NPN transistor, of a capacitor connected between an emitter of said transistor and grounding potential, and of a discharging switch.

The secondary constant current source may be also connected in two alternatives, viz. , in such a way that it is connected between the supply voltage source and the capacitor, i.e., it is connected before the switch, or it is connected to the supply voltage source and after the switch, when it is also connected to the main load.

The proposed apparatus may be utilized anywhere in the sphere of electrical engineering for converting the electric signal frequency to voltage. It enables a selective and linear conversion of a frequency input signal to an output voltage, at a simultaneous suppression of the influence of changes of supply voltage and/or temperature. The apparatus does not require expensive materials. It may be easily overtuned and/or applied in a wide frequency range. This makes it possible to change the slope of the frequency-to-voltage conversion.

## BRIEF DESCRIPTION OF DRAWINGS

The invention is explained in more detail by means of drawings where Fig. 1 to Fig. 4 show alternative embodiments of the apparatus according to the invention.

## MODES FOR CARRYING OUT THE INVENTION

### Example I

The apparatus for converting frequency of a signal to voltage, the circuit of which is shown in Fig. 1, is, according to our opinion, an example of the optimum embodiment according to the invention.

An input electric signal is connected to a constant pulse duration generator 1. After the constant pulse duration generator 1 there is connected a switch 2 to which a primary current source 3 is connected. Said primary current source 3 is connected to a supply voltage source 4, so that it is controlled by means of the supply voltage. A capacitor 5 is connected between the primary current source 3 and the switch 2. After the switch 2 there is connected a main load 6, connected to the supply voltage source 4, so that it is controlled by means of the supply voltage. Between the switch 2 and the main load 6, there is connected an auxiliary constant current load 7 which is also connected to the apparatus output, so that it is controlled by means of the output voltage from a frequency low-pass filter 8.

The apparatus works as follows: In the constant pulse duration generator 1, the input periodical electrical signal starts a pulse of a constant duration, viz., in every period, and, eventually, in every half-period. Said pulse switches ON the switch 2 within its duration, and the capacitor 5 is discharged, in the same moment, through a constant quantity of the electric charge. The electric charge permanently flows into the capacitor 5. If the quantity of the electric charge which passes away from capacitor 5 within the pulse duration is larger than the quantity of the electric charge which flows into it during the period, eventually half-period, of the input signal from the primary current source 3, the electric charge in the capacitor 5 starts decreasing, and in this way voltage across the capacitor 5 is decreased simultaneously as well. The frequency low-pass filter 8 suppresses the voltage ripple across the output of the apparatus caused by the charging and discharging of the capacitor 5. Voltage across the output of the apparatus is represented in this case by voltage across the output of the frequency low-pass filter 8. Said voltage controls the auxiliary constant current load 7 in such a way that with the decreasing voltage there increases the current passing through the auxiliary constant current load 7. This results in a rise of a positive feed-back which introduces a hystheresis and causes the slope increase of the frequency input signal to voltage conversion.

When increasing the supply voltage from the supply voltage source 4, the current value supplied through the primary current source 3 is increased, and simultaneously, the charge quantity taken from the capacitor 5 by the main load 6 during the ON position of the switch 2. Both effects are eliminated in this way, and the influence of the increased supply voltage from the supply voltage source 4 to the function of the circuit is suppressed. A thermal influence which increases the current value supplied by the primary current source 3 increases, at the same time, the charge quantity taken away from the capacitor 5 of the main load 6 during the ON position of the switch 2. Both effects are eliminated in this way, and the thermal influence as to the function of the circuit is suppressed. The decrease of the supply voltage from the supply voltage source 4 decreases the current value supplied by the primary current source 3, and at the same time, there is also decreased the charge quantity taken from the capacitor 5 by the main load 6 within the ON position of the switch 2. Both effects are eliminated in this way, and the influence of the decrease of the supply voltage from the supply voltage source 4, as to the function of the circuit, is suppressed. The thermal influence which decreases the current value supplied by the primary current source 3, decreases at the same time the charge quantity taken from the capacitor 5 by the main load 6 within the period of the ON position of the switch 2. Both effects are eliminated in this way, and the thermal influence, as to the circuit function, is suppressed.

At an identical connection, voltage across the output of the frequency low-pass filter 8 may, on the contrary, affect the auxiliary constant current load 7 in such a way that, with the decreasing voltage, the current, passing through the auxiliary constant current load 7, is decreased. This results in a rise of a negative feed-back which causes a slope decrease of the conversion of the input signal frequency to voltage.

The apparatus could function even without the control by means of the supply voltage source 4 of the primary current source 3 and of the main load 6, but the suppression influence of changes of the supply voltage would not be

achieved. The apparatus could also function without the frequency low-pass filter 8 and the auxiliary constant current load 7, but a ripple suppression of voltage across the output of the apparatus, as well as the required slope of the frequency to voltage conversion could not be ensured.

The alternative mentioned in this exemplary embodiment may be considered as the most advantageous because of the fact that, with respect to the circuit embodiment, it is easier to realize the auxiliary constant current load 7, one pole of which is connected to the grounding potential, than to realize the constant current source 9 connected to the supply voltage source 4.

Example 2

An apparatus, the circuit of which is shown in Fig. 2, is another embodiment according to the invention.

The apparatus is similar to the preceding one, but it differs in the fact that the auxiliary constant current load 7 is connected to the capacitor 5 and before the switch 2, and simultaneously, it is connected to the primary current source 3 and to the output of the frequency low-pass filter 8, so that it is controlled by the output voltage.

The apparatus is functioning analogously as the apparatus according to example 1.

Example 3

An apparatus, the circuit of which is shown in Fig. 3, is another embodiment according to the invention.

The apparatus is similar to that in example 2, but it differs in that in this circuit there is not included the auxiliary constant current load 7; the secondary

constant current source 9 is connected there. Said secondary constant current source 9 is connected between the supply voltage source 4 and the capacitor 5, and simultaneously, it is connected to the output of the apparatus, i.e., to the output of the frequency low-pass filter 8, so that it is controlled by the output voltage of the frequency low-pass filter 8.

The apparatus works as follows: The input periodical electrical signal starts, in the constant pulse duration generator 1, a pulse of a constant duration, viz., in every period, and, eventually, in every half-period. Said pulse switches ON, within its duration, the switch 2 and the capacitor 5 is discharged in the same moment by a constant quantity of the electric charge. The electric charge is permanently flows into the capacitor 5. If the quantity of the electric charge, which passed away from the capacitor 5 within the pulse duration, is larger than the quantity of the electric charge which flows into the capacitor 5 during the period, eventually half-period, of the input signal from the primary current source 3, the electric charge in the capacitor 5 starts decreasing, and in this way voltage across the capacitor 5 is decreased simultaneously as well. The frequency low-pass filter 8 suppresses the voltage ripple across the output of the apparatus caused by charging and discharging the capacitor 5. Voltage across the output of the frequency low-pass filter 8 also controls the secondary constant current source 9 in such a way that, at the decreasing voltage, current flowing out of the secondary constant current source 9 is increased. This results in a rise of a negative feed-back which causes the slope decrease of the frequency input signal to voltage conversion. The influence of the increase or decrease of the supply voltage, as well as thermal influences, are suppressed in the same way as in the preceding example.

At an identical connection, voltage across the output of the apparatus, i.e., at the output of the frequency low-pass filter 8, may, on the contrary, affect the secondary constant current source 9 in such a way that, with the decreasing voltage, the current flowing out of the secondary constant current source 9 is decreased. This results in a rise of a positive feed-back which

introduces a hystheresis and increases the slope of the input signal frequency to voltage conversion.

The apparatus could function even without control by means of the supply voltage source 4 of the primary current source 3 and of the main load 6, but a suppression of the influence of changes of the supply voltage would not be achieved. The apparatus could also function without the frequency low-pass filter 8 and the secondary constant current source 9, but a ripple suppression of voltage across the output of the apparatus, as well as the required slope of the frequency to voltage conversion could not be ensured.

Example 4

An apparatus, the circuit of which is shown in Fig. 4, is another embodiment according to the invention.

The apparatus is similar to that in example 3, but it differs in that the secondary constant current source 9 is connected to the supply voltage source 4 and to the main load 6, and simultaneously, it is connected to the output of the apparatus, so that it is controlled by the output voltage of the frequency low-pass filter 8.

The apparatus functions in an analogous way as the apparatus according to the preceding example.

CLAIMS

1. An apparatus for converting frequency of an electric signal to voltage, said apparatus comprises a circuit, where the input electric signal is connected to a constant pulse duration generator, after which a switch is connected, being connected to a primary current source, which primary current source is connected between a supply voltage source and a capacitor, and one pole of the capacitor is connected between the switch and the primary current source, c h a r a c t e r i z e d by the fact that after the switch (2) there is connected a main load (6) consisting of a circuit for taking away a constant charge quantity from the capacitor (5) within the ON position of the switch (2).

2. The apparatus as in Claim l, w h e r e i n the main load (6) is connected to a supply voltage source (4).

3. The apparatus as in Claim l and 2, w h e r e i n its electric circuit is provided with a frequency low-pass filter (8), connected between the capacitor (5) and the output of the apparatus.

4. The apparatus as in Claim 3, w h e r e i n its circuit is provided with an auxiliary constant current load (7), which is connected to the apparatus output.

5. The apparatus as in Claim 4, w h e r e i n one pole of the auxiliary constant current load (7) is connected to the capacitor (5).

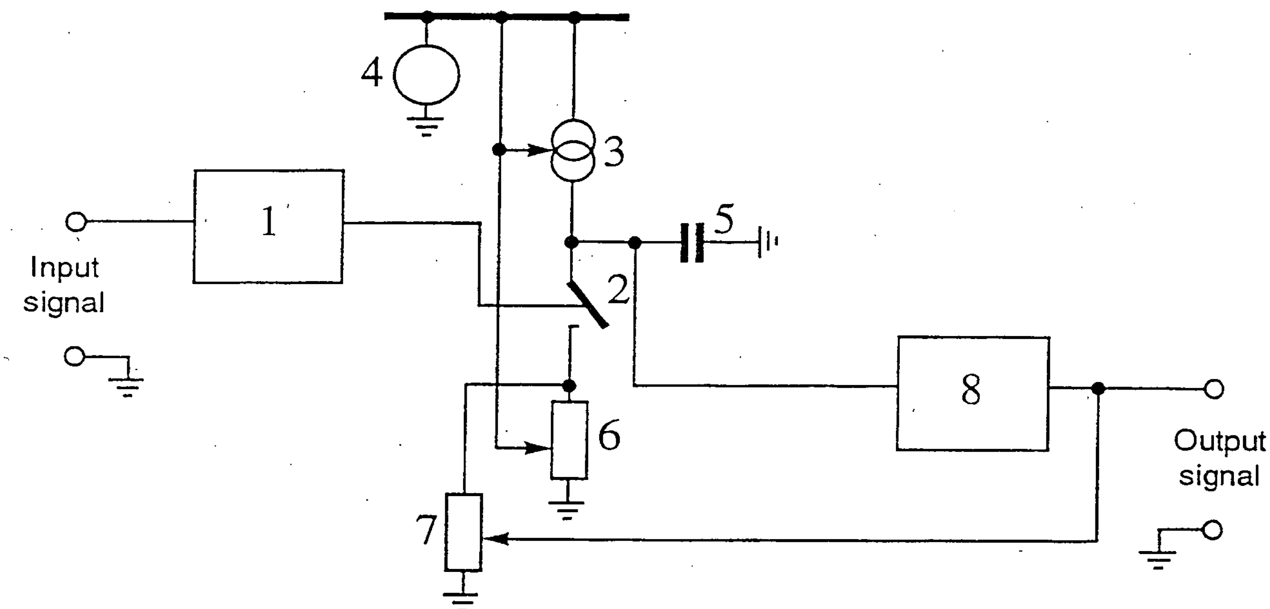
6. The apparatus as in Claim 4, w h e r e i n one pole of the auxiliary constant current load (7) is connected between the switch (2) and the main load (6).

7. The apparatus as in Claim 3, w h e r e i n its circuit is provided with a secondary constant current source (9) connected to the apparatus output.

8. The apparatus as in Claim 7, w h e r e i n one pole of the secondary constant current source (9) is connected to the capacitor (5).

9. The apparatus as in Claim 7, w h e r e i n one pole of the secondary constant current source (9) is connected to the switch (2) and to the main load (6).

Fig. 1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6
Output
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7

Fig. 2

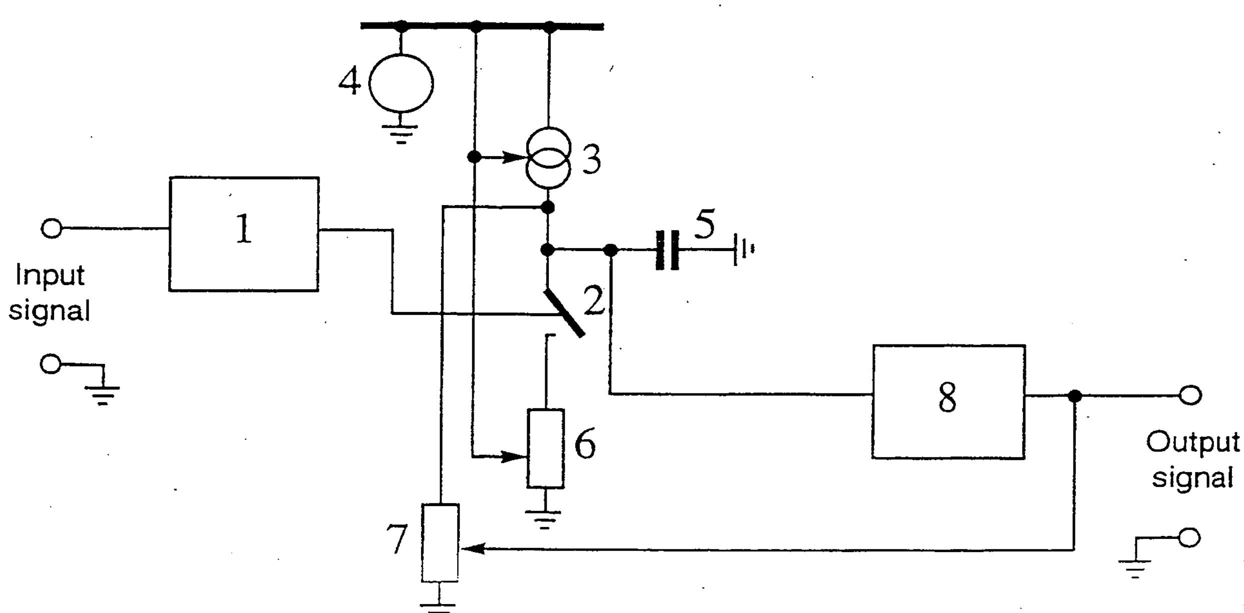
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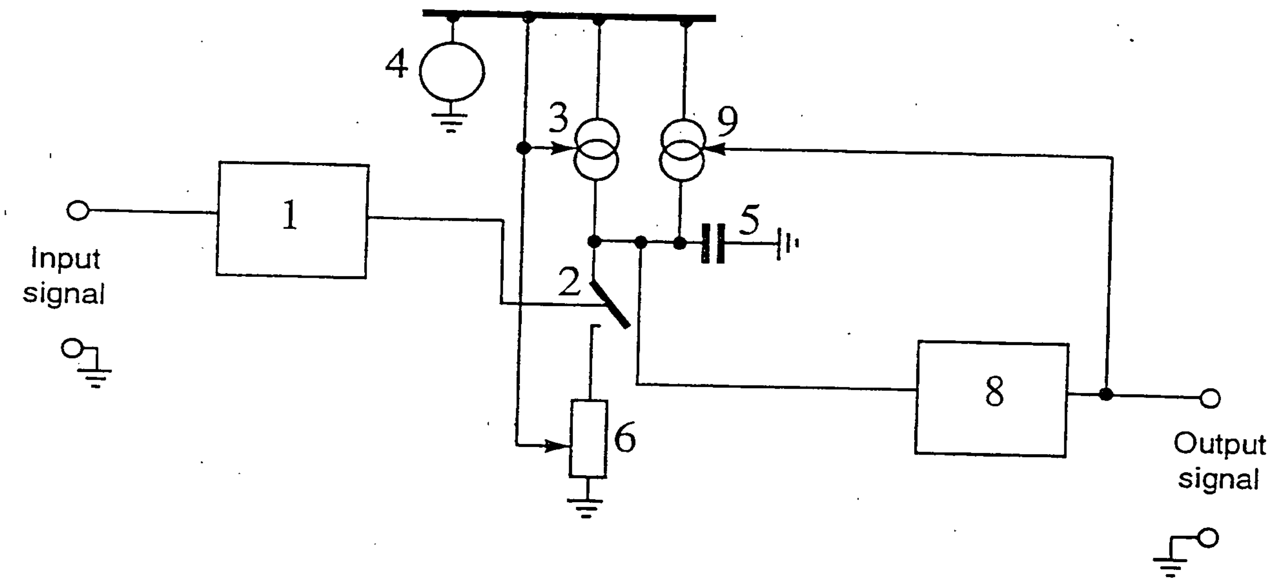
Fig. 3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Output
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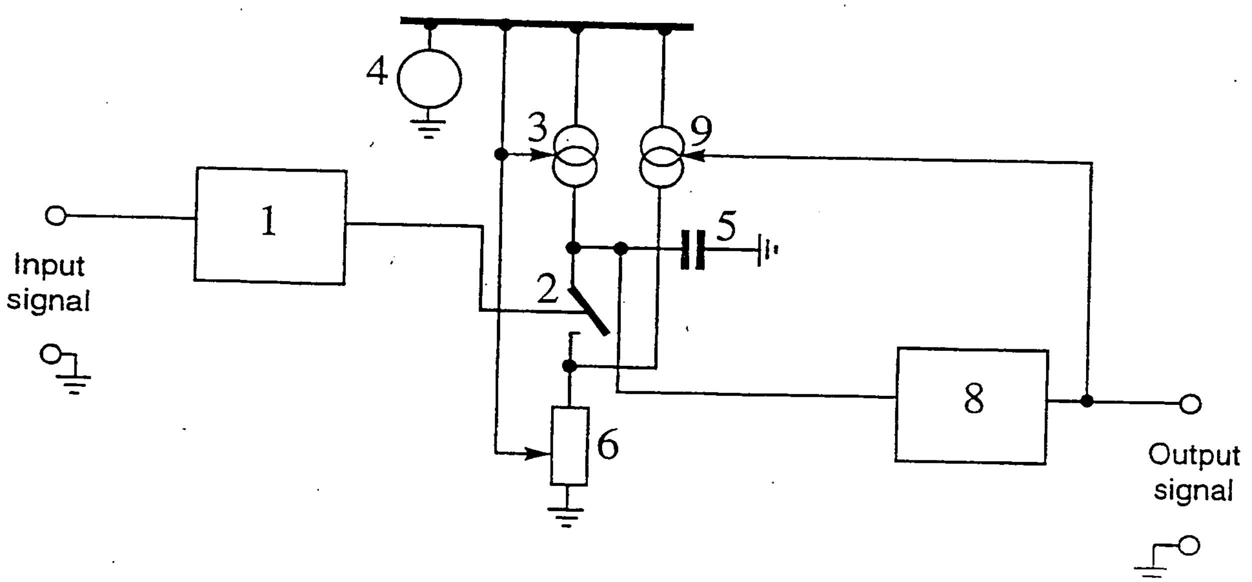
Fig. 4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Output
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# INTERNATIONAL SEARCH REPORT

International Application No
PCT/CZ 98/00022

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 H03K9/06

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H03K H03D H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>A | US 4 350 957 A (Y. MIYAMOTO) 21 September 1982<br>see column 3, line 16 - line 47; figure 3 | 1,3<br>2 |
| A | US 5 514 988 A (V. SCHRADER ET. AL.) 7 May 1996<br>see column 2, line 25 - column 4, line 19; figures 2A,2B | 1 |
| A | US 3 742 252 A (R. BRZOSTEK) 26 June 1973<br>see column 2, line 14 - column 4, line 31; figures 1-3<br>see column 1, line 35 - line 40 | 1 |
| A | EP 0 251 239 A (NEC CORP,) 7 January 1988<br>see page 3, line 48 - page 4, line 6; figure 4<br>see page 2, line 4 - line 12 | 1,3 |

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| 13 July 1998 | 20/07/1998 |

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 4 222 095 A (M. STEIN) 9 September 1980<br>cited in the application<br>see column 2, line 37 - column 3, line 13;<br>figures 1,2<br>----- | 1 |

1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CZ 98/00022

| Patent document cited in search report | | Publication date | Patent family member(s) | | | Publication date |
|---|---|---|---|---|---|---|
| US 4350957 | A | 21-09-1982 | NONE | | | |
| US 5514988 | A | 07-05-1996 | US | 5621341 | A | 15-04-1997 |
| US 3742252 | A | 26-06-1973 | NONE | | | |
| EP 251239 | A | 07-01-1988 | JP | 63009211 | A | 14-01-1988 |
| | | | AU | 591856 | B | 14-12-1989 |
| | | | AU | 7480087 | A | 07-01-1988 |
| | | | CA | 1287883 | A | 20-08-1991 |
| | | | DE | 3781604 | A | 15-10-1992 |
| | | | US | 4800338 | A | 24-01-1989 |
| US 4222095 | A | 09-09-1980 | NONE | | | |